Preprints.org

Article

Not peer-reviewed version

GLP-1 Receptor Agonists Reduce Liver Stiffness in a Pediatric MASLD Cohort and Normalize Disease-Associated Core Gene Expression in a MASLD Model

Ella Findling , Terrence Bissoondial [†] , Prakash Narayan [*,†]

Posted Date: 11 March 2026

doi: 10.20944/preprints202603.0905.v1

Keywords: pediatric; diabetes; obesity; MASLD; liver; GLP-1 receptor agonist; transcriptomic; fibrosis

Preprints.org is a free multidisciplinary platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This open access article is published under a Creative Commons CC BY 4.0 license, which permit the free download, distribution, and reuse, provided that the author and preprint are cited in any reuse.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 11 March 2026 doi:10.20944/preprints202603.0905.v1

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

Article

GLP-1 Receptor Agonists Reduce Liver Stiffness in a Pediatric MASLD Cohort and Normalize Disease-Associated Core Gene Expression in a MASLD Model

Ella Findling [1], Terrence Bissoondial [1,†] and Prakash Narayan [2,*,†]

[1] George W. Hewlett High School, 60 Everit Ave, Hewlett, NY 11557, USA
[2] Nodes and Edges LLC, 4030 Wake Forest Rd, Ste 349, Raleigh, NC 27609, USA
* Correspondence: admin@nodesnedges.com
† These authors contributed equally to this work.

Abstract

Metabolic dysfunction-associated steatotic liver disease (MASLD) is the most common chronic liver disease in children and is strongly associated with obesity and insulin resistance. In this study, we evaluated the clinical effects of GLP-1 RA therapy in a de-identified cohort of pediatric patients with MASLD and investigated potential molecular mechanisms using publicly available transcriptomic datasets from models of liver disease. Longitudinal FibroScan measurements from seven pediatric patients treated with GLP-1 RAs demonstrated significant reductions in controlled attenuation parameter scores, transient elastography scores and AST levels, indicating improvements in hepatic steatosis, liver stiffness and the liver inflammatory profile, respectively. To explore potential mechanisms underlying these observations, we analyzed transcriptomic datasets from methionine-choline deficient (MCD) and high-fat diet (HFD) mouse models of liver disease. A pattern-matching algorithm identified a core set of ten genes consistently upregulated in both models and downregulated following GLP-1 RA treatment in the HFD model. These genes are enriched in extracellular matrix remodeling, inflammatory signaling, and fibrogenic pathways associated with hepatic stellate cell activation. Collectively, these findings suggest that GLP-1 RA therapy may improve pediatric MASLD by attenuating fibrogenic and inflammatory transcriptional programs. Although limited by a small cohort size, this integrated clinical-transcriptomic approach supports further investigation of GLP-1 receptor agonists as a therapeutic strategy for pediatric MASLD.

Keywords: pediatric; diabetes; obesity; MASLD; liver; GLP-1 receptor agonist; transcriptomic; fibrosis

Introduction

Metabolic dysfunction-associated steatotic liver disease (MASLD) is the most common pediatric chronic liver disease, affecting 5–11% of all children, with rates rising to 30–50% in children with obesity [1]. Left untreated, MASLD can progress to metabolic dysfunction-associated steatotohepatitis (MASH), fibrosis and increases the risk for early hepatocellular carcinoma especially in children with obesity and insulin resistance [2–4]. In addition to attendant symptoms and comorbidities that effectively steal childhood, pediatric MASLD is associated with a 40-fold higher risk of early mortality in young adulthood and the need for liver transplant in young adults [5].

The MASLD continuum is driven primarily by insulin resistance which promotes the accumulation of hepatic fat [6,7]. With time, metabolic stress and steatosis trigger inflammatory pathways and cellular injury, promoting the transition to MASH or steatosis with inflammation [8,9]. Chronic injury activates hepatic stellate cells (HSCs), which start secreting excessive matrix

© 2026 by the author(s). Distributed under a Creative Commons CC BY license.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 11 March 2026 doi:10.20944/preprints202603.0905.v1

disrupting structures within the liver, impairing blood flow and stiffening liver tissue [10–13]. Management of pediatric MASLD relies on lifestyle and diet modifications as frontline therapy [14]. Nevertheless, sustaining these changes is challenging; other patients are refractory to such changes. Over the last decade, adult patients with metabolic diseases have benefited from novel therapeutics including glucagon-like peptide-1 receptor agonists (GLP-1 RAs) which have positively impacted end organs including the kidneys and liver [15,16]. In the present study we evaluated use of GLP-1 RAs in a de-identified pediatric MASLD cohort and investigated its putative mechanism of action by analyzing publicly available transcriptomic datasets from murine models of liver disease.

Methods

Clinical Data

To evaluate the efficacy of GLP-1 RA, we analyzed longitudinal FibroScan (Echosens, Paris, France) data from a cohort of seven pediatric patients. De-identified clinical data was obtained from Northwell Health, NY following Institutional Review Board (IRB) approval (#25-1020, Glucagon-Like Peptide-1 Receptor Agonists Reduce Hepatic Steatosis and Fibrosis in Pediatric Metabolic Dysfunction-Associated Steatotic Liver Disease). Inclusion criteria required a diagnosis of class 2 or higher obesity with MASLD and a minimum of three months of therapy with a GLP-1 RA. Noninvasive vibration-controlled transient elastography was utilized to assess hepatic steatosis (controlled attenuation parameter (CAP) score) and liver stiffness (transient elastography (TE) score) [17]. Liver function tests (aspartate aminotransferase (AST) and alanine aminotransferase ALT) were made from blood draws and the de Ritis ratio calculated [18].

Transcriptomic Analyses from MASLD Models

Transcriptomic datasets were retrieved from the NCBI Gene Expression Omnibus (GEO). Two specific datasets were selected: GSE267124, consisting of 12 mice fed a methionine-choline deficient (MCD) diet to induce advanced fibrosis, and GSE243681, consisting of mice with high fat diet (HFD)-induced obesity treated with a GLP-1 RA [19]. Raw mRNA counts were processed using iDEP 2.0 (South Dakota State University, SD) for normalization and principal component analysis (PCA). A pattern matching algorithm was used to identify core genes common to both studies. Core genes were fed to GepLiver (Home-GepLiver) for evaluation of their expression across murine models of MASLD. Humanbase (HumanBase: data-driven predictions of gene function and interactions) and Gene Ontology (GO) Biological Process (BP) (Gene Ontology Resource) were used to visualize core gene interaction and pathway activation signatures, respectively.

Statistical Analysis

Effects of GLP-1 RAs on clinical parameters were compared using a paired two-tailed test or a Wilcoxon Signed-Rank test (non-parametric), and a Fisher's exact test for responses. Differentially expressed genes from murine models were identified using a two-tailed t-test. A $p<0.05$ was considered statistically significant.

Results

All patients, male and female, were < 18 years of age at the onset of treatment, presented with class 2 or higher obesity and were on GLP-1 RA (Wegovy or Ozempic) therapy for at least 3 months (Table 1). One patient was on Zepbound which is a GLP-1 RA+glucose-dependent insulinotropic polypeptide (GIP). Comorbidities and concomitant medications are listed. Patients recorded a decrease in body mass index (BMI) and/or weight with therapy (Table 1). Prior to initiation of therapy, liver CAP scores (Table 1) were indicative of hepatic steatosis (upper limit of normal, 225 dB/m) [20]. Liver TE scores, also elevated (upper limit of normal, 6.5 kPa) [20] prior to initiation of

© 2026 by the author(s). Distributed under a Creative Commons CC BY license.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 11 March 2026 doi:10.20944/preprints202603.0905.v1

therapy, were reflective of liver stiffening; elevated liver function tests indicated inflammation (Table 1).

Table 1. Patient level data for MASLD cohort prior to (salmon) and following (green) GLP-1 RA administration. *Zepbound has GLP-1 RA+GIP activity.

GLP-1 RA	Wegovy	Wegovy	Wegovy	Zepbound*	Wegovy	Wegovy	Ozempic
Concomitant Medications	Synthroid	Atenolol		Vitamin E	Vitamin E		Metformin
		Enalapril		Wellbutrin			
Age (years) at Onset	17	17	17	17	17	15	17
Sex	F	M	F	M	M	M	M
Comorbidities	Class 2 obesity	Class 2 obesity	Class 2 obesity	Class 2 obesity	Class 3 obesity	Class 2 obesity	Class 3 obesity
	Cong hypothyroid		Pre-diabetes	OSA	Dyslipidemia	Pre-diabetes	Diabetes
	Irregular menses		PCOS			Dyslipidemia	
pre-GLP1 RA							
BMI (kg/m2)	35.7	38.4	36.5	37.9	45.9	33.5	40.5
Weight (pounds)	198	223	201	254	283	240	298
AST (U/L)	90	24	31	91	59	147	54
ALT (U/L)	120	37	57	126	118	336	91
HbA1C	5.7	5.7	5.7	5.5	5.2	6.3	7.1
CAP (dB/m)	344	398	234	379	311	365	396
TE (kPa)	13	7.9	8.6	7.9	11.1	13.4	16.5
Months on GLP-1 RA	3	3	5	8	8	3	3
post-GLP-1 RA							
BMI (kg/m2)	33.6	36.5	33.1	36.2	40.4	31.4	39.5
Weight (pounds)	189	213	179	245	246	218	290
AST (U/L)	76	25	21	79	14	29	51
ALT (U/L)	122	44	20	98	12	75	59
HbA1C	5.4	5.4	5.1	5.2	5.1	5.3	6.6
CAP (dB/m)	240	339	190	305	260	308	295
TE (kPa)	10.8	6.9	6.6	7	4.5	10.2	11.1

Prior to initiation of therapy, each patient within this cohort exhibited a de Ritis ratio (AST/ALT) < 1, consistent with a diagnosis of MASLD (Figure 1).

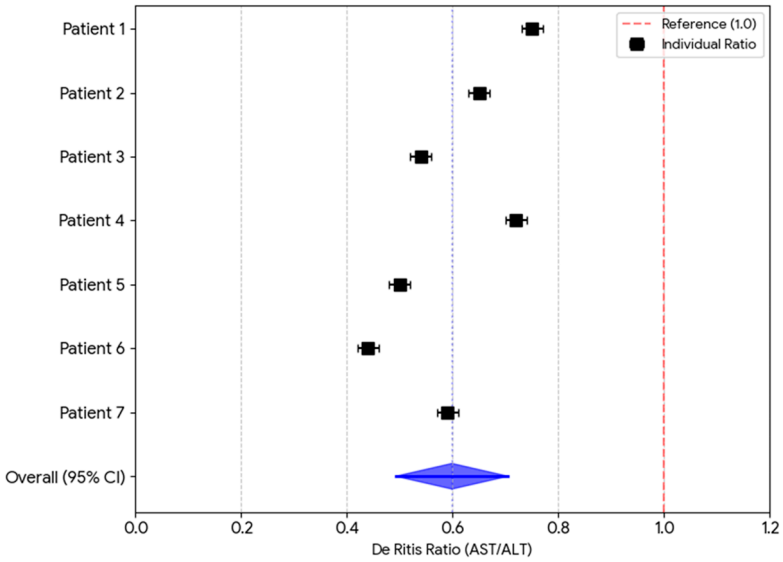

Figure 1. De Ritis Ratios in Pediatric MASLD Cohort. Prior to initiation of therapy each patient exhibited a De Ritis ratio <1.

Administration of a GLP-1 RA was associated with a reduction in liver CAP scores (Figure 2A), liver TE scores (Figure 2B and AST levels (Figure 2C). In fact, most patients responded to drug with a reduction in each of these parameters. The reduction in ALT levels with GLP-1 RA was not significant (data not shown).

Liver TE scores are a surrogate for liver scarring [21] and treatment with GLP-1 RAs was associated with a reduction in this score. We sought to delineate the mechanism of action of GLP-1 RAs using murine models of liver disease. Analysis of datasets GSE267124 (MCD diet model) and GSE243681 (HFD and HFD+GLP-1 RA model) revealed a distinct separation between treatment groups (control vs. MCD diet, Figure 3A; HFD vs. HFD+GLP-1 RA, Figure 3B) and both up- and downregulated genes (Figure 3C,D).

© 2026 by the author(s). Distributed under a Creative Commons CC BY license.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 11 March 2026 doi:10.20944/preprints202603.0905.v1

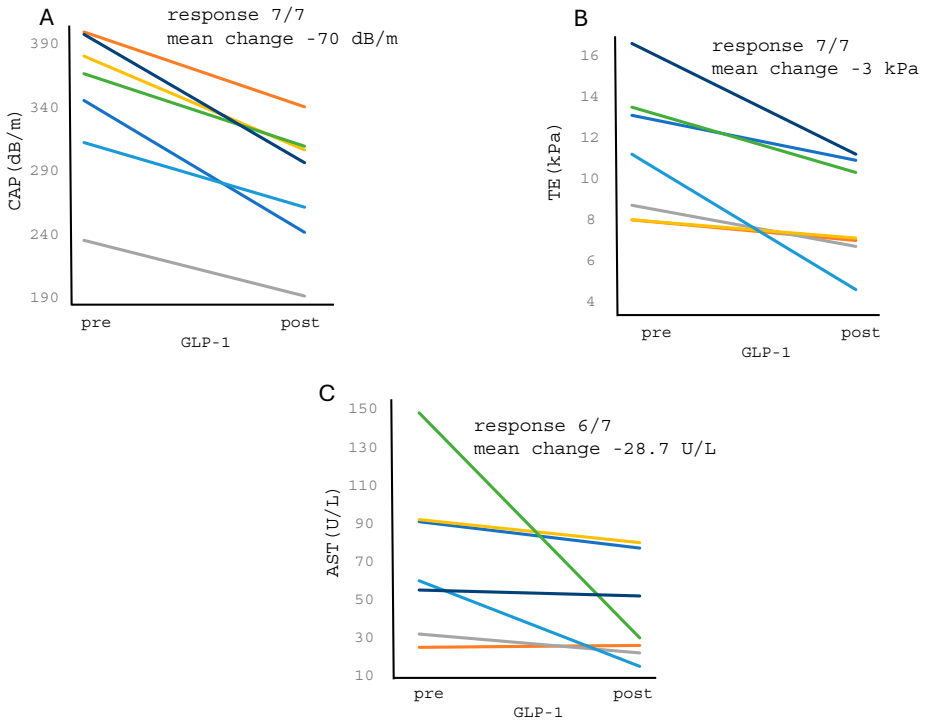

Figure 2. Effects of GLP-1 RAs on Liver Parameters. Treatment with a GLP-1 RA was associated with a reduction in (A) CAP scores (p<0.01), (B) TE scores (p=0.01) and (C) AST (p=0.05). Both CAP and TE scores recorded a 100% response rate (p<0.01) to therapy whereas 6/7 patients exhibited a reduction in AST levels (p=0.015).

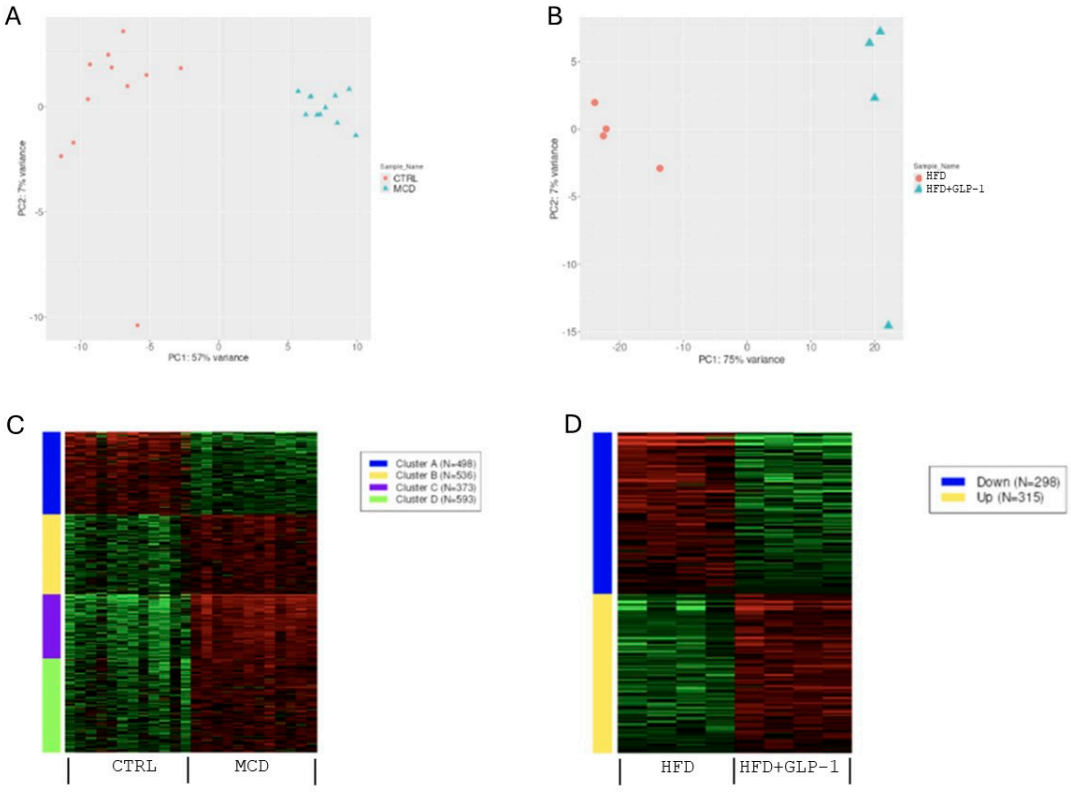

Figure 3. Transcriptomic Analysis in Murine Models of Liver Disease. PCA plots from MCD (A) and B) HFD and HFD+GLP-1 RA models of murine liver disease. C) and D) Up- and down-regulated genes from these models. Study details can be found in GSE267124 and GSE2436.

© 2026 by the author(s). Distributed under a Creative Commons CC BY license.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 11 March 2026 doi:10.20944/preprints202603.0905.v1

A pattern matching algorithm identified 10 core genes significantly upregulated in both models of liver disease and downregulated with GLP-1 RA treatment in the HFD model (Figure 4A and B). Seeding these genes into HumanBase indicates that these genes from a robust interactome interactome in the liver (Figure 4C, HumanBase).

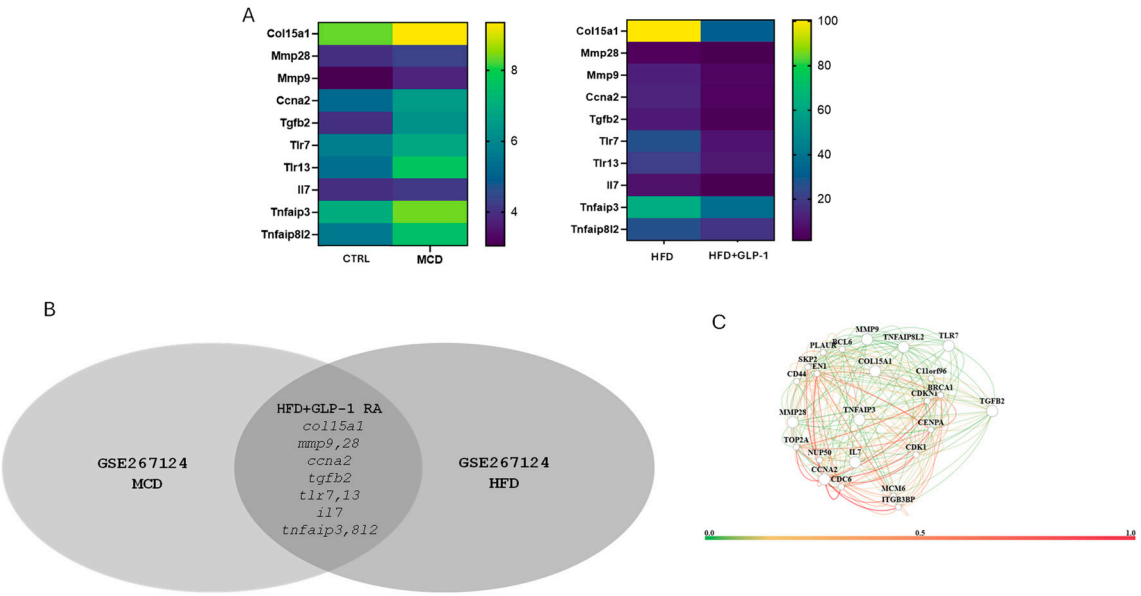

Figure 4. Core Gene Identification in MASLD Models. (A and B) A set of 10 genes was upregulated in the MCD diet and HFD models with expression levels reversed with GLP-1 RA treatment in the HFD model. C) Seeding these genes into HumanBase revealed a robust interactome in liver tissue.

Additional evidence for the role of these genes in MASLD was derived by seeding them into GepLiver. Expression levels of 9 out of 10 of these genes are elevated in models of murine MASLD (Table 2).

Table 2. Core genes identified in our analysis are overexpressed in other murine models of MASLD.

Gene	Healthy mice liver mRNA expression nomalized	MASLD mice liver mRNA expression nomalized
tgfß2	0.29	1.17
col15a1	4.08	5.71
mmp9	0.34	1.04
mmp28	0.13	0.42
il7	0.17	0.44
tlr7	1.28	6
ccna2	0.83	2.31
tnfaip3	1.47	7.74
tnfaip8l2	3.04	6.53

To determine the biological pathways associated with GLP-1 RA activity in MASLD, the core genes were seeded into GOBP. Treatment with GLP-1 RA was associated with restitution of extracellular matrix (ECM) remodeling, matrix deposition, profibrotic and proinflammatory signaling and a dampening of a heightened injury response (Table 3).

© 2026 by the author(s). Distributed under a Creative Commons CC BY license.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 11 March 2026 doi:10.20944/preprints202603.0905.v1

Table 3. Mechanisms underlying the activity of GLP-1 RA in a MASLD model.

Gene	Pathway	MCD model	HFD model	HFD+GLP-1 model
col15a1, mmp9,28	ECM remodeling, active basement membrane disruption, collagen deposition	↑	↑	↓
tgfß2	profibrotic signaling	↑	↑	↓
tlr7,13, il7	innate immune sensors, cytokine signaling, inflammatory environment	↑	↑	↓
ccna2, tnfaip3,8l2	comensatory response to injury	↑	↑	↓

Discussion

This study integrates clinical observations from a pediatric MASLD cohort with transcriptomic analyses from experimental models of liver disease to explore the therapeutic potential and mechanistic basis GLP-1 RA therapy. Our findings demonstrate that treatment with GLP-1 RAs is associated with significant reductions in both hepatic steatosis (CAP score) and liver stiffness (TE score), suggesting improvements in both metabolic and fibrotic components of MASLD. Importantly, all patients in the cohort exhibited improvement in elastography-based measures, indicating a consistent clinical response despite the small sample size. To the best of our knowledge, this is the first report documenting a reduction in liver stiffness with a GLP-1 RA in a pediatric MASLD cohort.

Transient elastography provides a validated non-invasive surrogate for hepatic fibrosis and is increasingly used in both clinical and research settings to monitor disease progression and treatment responses in MASLD and related conditions [21]. Reductions in TE scores following GLP-1 RA therapy therefore suggest that these agents may not only reduce hepatic fat accumulation but also mitigate early fibrotic remodeling within the liver. Similar improvements in hepatic steatosis and fibrosis markers have been reported in adult MASLD and non-alcoholic steatohepatitis (NASH) cohorts treated with GLP-1-RAs supporting the translational relevance of our observations [22].

To explore the molecular basis for these clinical effects, we analyzed transcriptomic datasets from murine models of steatohepatitis and obesity-induced liver disease. A cross-model pattern matching strategy identified a core group of ten genes that were consistently upregulated during liver injury and suppressed following GLP-1 RA treatment. Indeed, use of the GepLiver search engine supported the roles of these core genes in experimental MASLD. Network analysis demonstrated that these genes form a tightly connected interactome in liver tissue, suggesting that they participate in coordinated regulatory pathways associated with disease progression. Importantly, pathway enrichment analyses revealed that these genes are strongly associated with extracellular matrix remodeling, collagen deposition, inflammatory signaling, and injury response pathways—all hallmarks of HSC activation and fibrogenesis [23].

Activation of HSCs represents a central event in the development of liver fibrosis. Upon liver injury, stellate cells transition from a quiescent state to a myofibroblast-like phenotype characterized

© 2026 by the author(s). Distributed under a Creative Commons CC BY license.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 11 March 2026 doi:10.20944/preprints202603.0905.v1

by increased production of extracellular matrix proteins such as collagen and fibronectin [24]. Persistent activation of this program leads to excessive matrix deposition, tissue stiffening, and architectural distortion of the liver. The suppression of genes associated with extracellular matrix production and inflammatory signaling observed in GLP-1 RA–treated models therefore provide a plausible mechanistic explanation for the reductions in liver stiffness observed in the clinical cohort.

Several biological mechanisms may contribute to these transcriptional effects. GLP-1 RA improves insulin sensitivity, reduces hepatic lipotoxicity, and promotes weight loss, all of which reduces metabolic stress within hepatocytes [25]. In addition, GLP-1 signaling has been shown to suppress inflammatory cytokine production and oxidative stress, both of which are key drivers of stellate cell activation [26]. Furthermore, GLP-1–based therapies may exert direct hepatic effects through modulation of lipid metabolism, mitochondrial function, and immune cell signaling within the liver microenvironment [27].

Limitation of this study should be acknowledged. The primary limitation of the present study is the small clinical cohort size, which limits the generalizability of the results. Although the observed responses were statistically significant and consistent across patients, larger multi-center studies will be required to confirm these findings. Additionally, the mechanistic analyses were derived from murine transcriptomic datasets rather than human liver samples. Future studies should evaluate gene expression changes directly in pediatric MASLD patients receiving GLP-1 RA therapy to determine whether the transcriptional signatures observed in murine models are conserved in humans. Longitudinal biopsy or circulating transcriptomic studies may provide further insight into the molecular processes underlying therapeutic response. Nevertheless, the integration of clinical outcomes with system-level transcriptomic analyses provides a framework for identifying molecular pathways associated with therapeutic response. By linking improvements in liver stiffness to the suppression of fibrogenic gene networks, this study highlights potential transcriptional programs that may serve as biomarkers or therapeutic targets in MASLD.

Conclusions

This study provides evidence that GLP-1 RA therapy is associated with improvements in hepatic steatosis and liver stiffness in pediatric patients with MASLD. Integrative transcriptomic analyses from murine models of liver disease identified a core gene signature linked to extracellular matrix remodeling and inflammatory signaling that is reversed by GLP-1 RA treatment. These findings suggest that GLP-1 RAs may exert therapeutic effects not only through metabolic improvements but also by attenuating transcriptional programs that drive hepatic fibrosis. Co-opting aspects of the four-pillar strategy in place for treatment of type 2 diabetes and chronic kidney disease and adult MASLD may be an attractive therapeutic modality for the treatment of pediatric MASLD.

Institutional Review Board Statement: De-identified clinical data was obtained from Northwell Health, NY following Institutional Review Board approval (approval number #25-1020, Glucagon-Like Peptide-1 Receptor Agonists Reduce Hepatic Steatosis and Fibrosis in Pediatric Metabolic Dysfunction-Associated Steatotic Liver Disease, dated 02-12-2025).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Panganiban J, Kehar M, Ibrahim SH, Hartmann P, Sood S, Hassan S, Ramirez CM, Kohli R, Censani M, Mauney E, Cuda S, Karjoo S. Metabolic dysfunction-associated steatotic liver disease (MASLD) in children with obesity: An Obesity Medicine Association (OMA) and expert joint perspective 2025. Obes Pillars. 2025 Feb 1;14:100164.
2. Zöggeler T, Kavallar AM, Pollio AR, Aldrian D, Decristoforo C, Scholl-Bürgi S, Müller T, Vogel GF. Meta-analysis of shotgun sequencing of gut microbiota in obese children with MASLD or MASH. Gut Microbes. 2025 Dec;17(1):2508951.

© 2026 by the author(s). Distributed under a Creative Commons CC BY license.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 11 March 2026 doi:10.20944/preprints202603.0905.v1

3. Jain AK, Busgang SA, Gennings C, Yates KP, Schwimmer JB, Rosenthal P, Murray KF, Molleston JP, Scheimann A, Xanthakos SA, Behling CA, Carpenter D, Fishbein M, Neuschwander-Tetri BA, Tonasia J, Vos MB. Environmental toxicants modulate disease severity in pediatric metabolic dysfunction-associated steatohepatitis. J Pediatr Gastroenterol Nutr. 2024 Nov;79(5):943-953.
4. Ng NB, Sng AA, Huang JG. Fighting the epidemic of pediatric metabolic dysfunction-associated steatotic liver disease: Role of non-invasive diagnostics and early pharmacological intervention. World J Hepatol. 2026 Jan 27;18(1):111211.
5. Hartmann P, Mouzaki M, Hassan S, Kehar M, Mysore KR, Mauney E, Nonga D, Karjoo S, Sood S, Tou A, Brichta C, Herdes RE, Pai N, Garner DK, Rinella ME, Noureddin M, Younossi Z, Allen AM, Sanyal A, Kohut T, Kohli R, Ramirez CM, Xanthakos S, Vos MB, Schwimmer JB, Ibrahim SH, Panganiban J. Call to action-Pediatric MASLD requires immediate attention to curb health crisis. Hepatology. 2025 Nov 1;82(5):1341-1351.
6. Song K, Lee E, Lee HS, Youn YH, Baik SJ, Shin HJ, Chae HW, Lee JW, Kwon YJ. Identification of pediatric MASLD using insulin resistance indices. JHEP Rep. 2025 Apr 3;7(7):101419.
7. Song K, Lee E, Youn YH, Baik SJ, Shin HJ, Lee JW, Chae HW, Lee HS, Kwon YJ. Prediction Model for Insulin Resistance and Implications for MASLD in Youth: A Novel Marker, the Pediatric Insulin Resistance Assessment Score. Yonsei Med J. 2025 Aug;66(8):464-472.
8. Hwang A, Shi C, Zhu E, Naaz F, Zhou P, Rasheed Z, Liu M, Jung LS, Duan B, Li J, Jiang K, Paka L, Gadhiya SV, Dana D, Ali Q, Yamin MA, Goldberg ID, Narayan P. Supervised learning reveals circulating biomarker levels diagnostic of hepatocellular carcinoma in a clinically relevant model of non-alcoholic steatohepatitis; An OAD to NASH. PLoS One. 2018 Jun 26;13(6):e0198937.
9. Liao K, Pellicano AJ, Jiang K, Prakash N, Li J, Bhutkar S, Hu Z, Ali Q, Goldberg ID, Narayan P. Glycerol-3-phosphate Acyltransferase1 Is a Model-Agnostic Node in Nonalcoholic Fatty Liver Disease: Implications for Drug Development and Precision Medicine. ACS Omega. 2020 Jul 16;5(29):18465-18471.
10. Simonetto DA, Yang HY, Yin M, de Assuncao TM, Kwon JH, Hilscher M, Pan S, Yang L, Bi Y, Beyder A, Cao S, Simari RD, Ehman R, Kamath PS, Shah VH. Chronic passive venous congestion drives hepatic fibrogenesis via sinusoidal thrombosis and mechanical forces. Hepatology. 2015 Feb;61(2):648-59.
11. Kostallari E, Wei B, Sicard D, Li J, Cooper SA, Gao J, Dehankar M, Li Y, Cao S, Yin M, Tschumperlin DJ, Shah VH. Stiffness is associated with hepatic stellate cell heterogeneity during liver fibrosis. Am J Physiol Gastrointest Liver Physiol. 2022 Feb 1;322(2):G234-G246.
12. Ozturk A, Olson MC, Samir AE, Venkatesh SK. Liver fibrosis assessment: MR and US elastography. Abdom Radiol (NY). 2022 Sep;47(9):3037-3050.
13. Azevedo Silva M, Leal C, Gonçalves AR, Martins CA, Russo P, Fernandes A, Santos A, Cotrim I. Non-invasive liver fibrosis assessment: is transient elastography mandatory? Rev Esp Enferm Dig. 2023 Jul;115(7):394-395.
14. Khadilkar V, Shah N, Harish R, Ayyavoo A, Bang A, Basu S, Chatterjee S, Chhatwal J, Elizabeth KE, Ghate S, Gupta A, Kinjawadekar U, Kumar R, Mishra S, Sakamuri K, Saxena V, Singh H, Singh P, Sud A, Tiwari S. Indian Academy of Pediatrics Revised Guidelines on Evaluation, Prevention and Management of Childhood Obesity. Indian Pediatr. 2023 Dec 15;60(12):1013-1031.
15. Cooper ME, van Raalte DH. GLP-1 agonists in the treatment of chronic kidney disease in type 2 diabetes and obesity. J Clin Invest. 2025 Nov 3;135(21):e194749.
16. Chrysavgis LG, Kazanas S, Bafa K, Rozani S, Koloutsou ME, Cholongitas E. Glucagon-like Peptide 1, Glucose-Dependent Insulinotropic Polypeptide, and Glucagon Receptor Agonists in Metabolic Dysfunction-Associated Steatotic Liver Disease: Novel Medication in New Liver Disease Nomenclature. Int J Mol Sci. 2024 Mar 29;25(7):3832.
17. Lee YK, Lee DH, Joo SK, Jang H, So YH, Jang S, Lee DH, Park JH, Chang MS, Kim W; Innovative Target Exploration of NAFLD (ITEN) Consortium. Combi-Elastography versus Transient Elastography for Assessing the Histological Severity of Metabolic Dysfunction-Associated Steatotic Liver Disease. Gut Liver. 2024 Nov 15;18(6):1048-1059.
18. Shaikh SM, Varma A, Kumar S, Acharya S, Patil R. Navigating Disease Management: A Comprehensive Review of the De Ritis Ratio in Clinical Medicine. Cureus. 2024 Jul 13;16(7):e64447.

© 2026 by the author(s). Distributed under a Creative Commons CC BY license.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 11 March 2026 doi:10.20944/preprints202603.0905.v1

19. McGlone ER, Hope DCD, Davies I, Dore M, Goldin R, Jones B, Liu Z, Li JV, Vorkas PA, Khoo B, Carling D, Minnion J, Bloom SR, Tan TM. Chronic treatment with glucagon-like peptide-1 and glucagon receptor co-agonist causes weight loss-independent improvements in hepatic steatosis in mice with diet-induced obesity. Biomed Pharmacother. 2024 Jul;176:116888.
20. Rose PC, Cotton MF, Otwombe K, Innes S, Nel ED. Liver transient elastography values in healthy South African children. BMC Pediatr. 2023 Jul 13;23(1):355.
21. Castera L, Forns X, Alberti A. Non-invasive evaluation of liver fibrosis using transient elastography. J Hepatol. 2008 May;48(5):835-47.
22. Newsome PN, Buchholtz K, Cusi K, Linder M, Okanoue T, Ratziu V, Sanyal AJ, Sejling AS, Harrison SA; NN9931-4296 Investigators. A Placebo-Controlled Trial of Subcutaneous Semaglutide in Nonalcoholic Steatohepatitis. N Engl J Med. 2021 Mar 25;384(12):1113-1124.
23. Higashi T, Friedman SL, Hoshida Y. Hepatic stellate cells as key target in liver fibrosis. Adv Drug Deliv Rev. 2017 Nov 1;121:27-42.
24. Tsuchida T, Friedman SL. Mechanisms of hepatic stellate cell activation. Nat Rev Gastroenterol Hepatol. 2017 Jul;14(7):397-411.
25. Lee WY. New Potential Targets of Glucagon-Like Peptide 1 Receptor Agonists in Pancreatic β-Cells and Hepatocytes. Endocrinol Metab (Seoul). 2017 Mar;32(1):1-5.
26. Oh YS, Jun HS. Effects of Glucagon-Like Peptide-1 on Oxidative Stress and Nrf2 Signaling. Int J Mol Sci. 2017 Dec 22;19(1):26.
27. Lu X, Yang L. Glucagon-like peptide-1 and dual/triple receptor agonists in the treatment of metabolic dysfunction-associated steatotic liver disease: advances in mechanistic research. Front Med (Lausanne). 2026 Feb 12;13:1763185

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© 2026 by the author(s). Distributed under a Creative Commons CC BY license.